

Short Course on Experimental Dynamic Substructuring

Module #3: An industrial example



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Short Course Notes For:

February 1, 2014, IMAC, Orlando, Florida

Example 1 – FBS on a full car

This example is taken from the PhD thesis of Dennis de Klerk

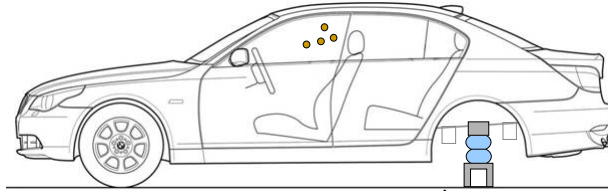
D. de Klerk. *Dynamic Response Characterization of Complex Systems through Operational Identification and Dynamic Substructuring: An application to gear noise propagation in the automotive industry*. PhD thesis, Delft University of Technology, Delft, The Netherlands, March 2009.

(download at repository of TU Delft library)

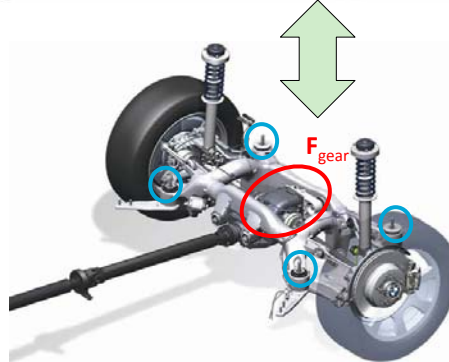
financed by BMW (D. Rixen supervisor)



Example 1 – FBS on a full car



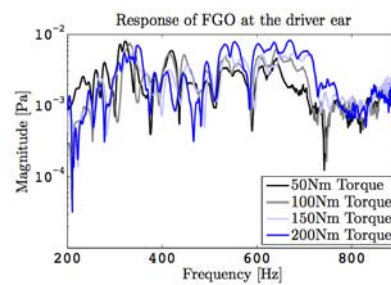
Predict the noise propagation
from differential to driver's ear.



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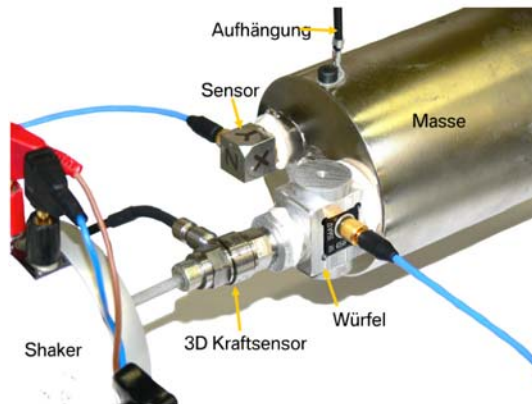
Example 1 – FBS on a full car



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Example 1 – FBS on a full car



Important to have excellent measurements with small positioning errors



→ measurement of driving points by exciting directly on a 3D-accelerometer

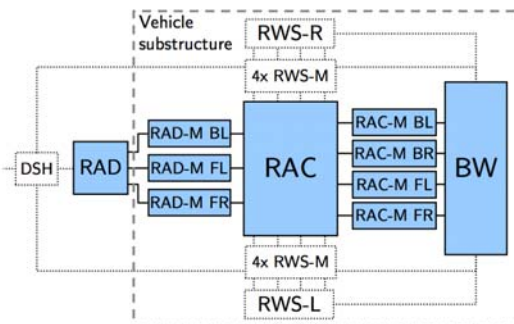


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Example 1 – FBS on a full car

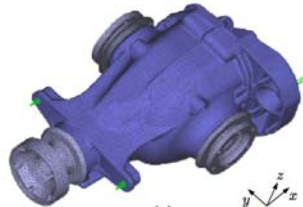
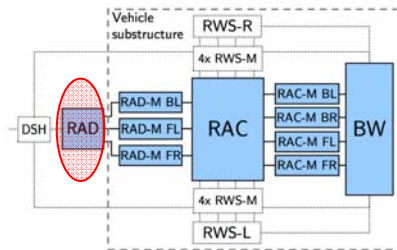
First approach: considering all subcomponents (measured or FE)



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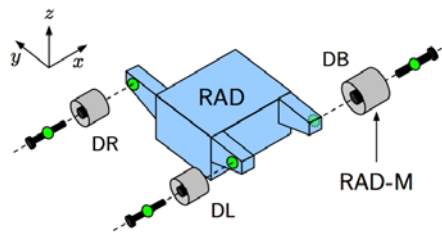
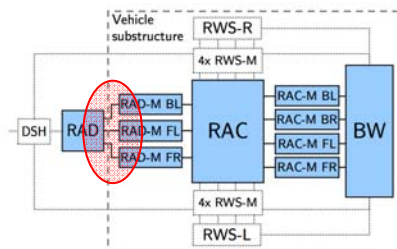
Example 1 – FBS on a full car



FE model and measurements give very similar FRFs (mainly rigid)



Example 1 – FBS on a full car



● - FE interface node (all DoF)

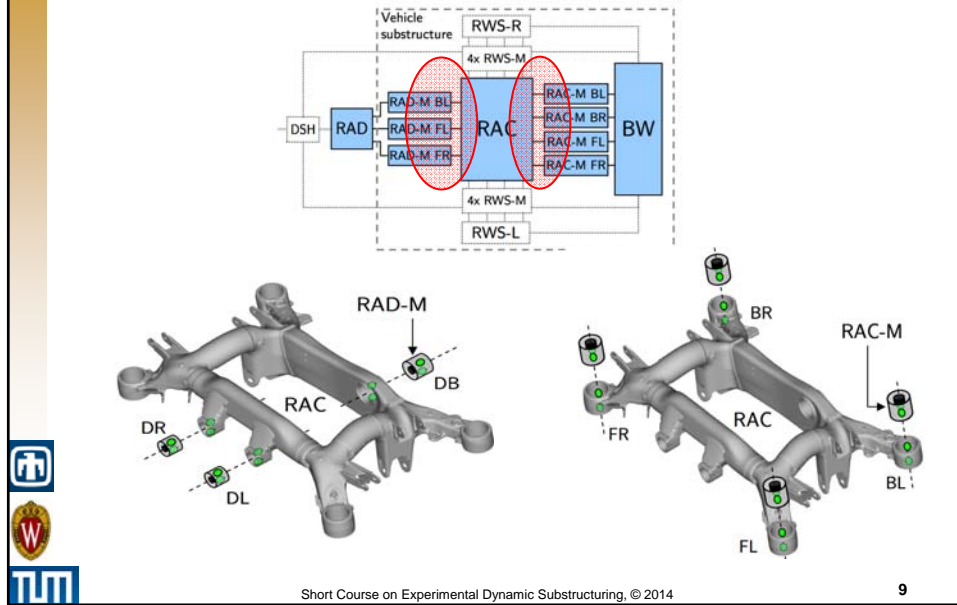


- Legend:
- 1: Core
 - 2: Lower Shell
 - 3: Upper Shell
 - 4: Rubber

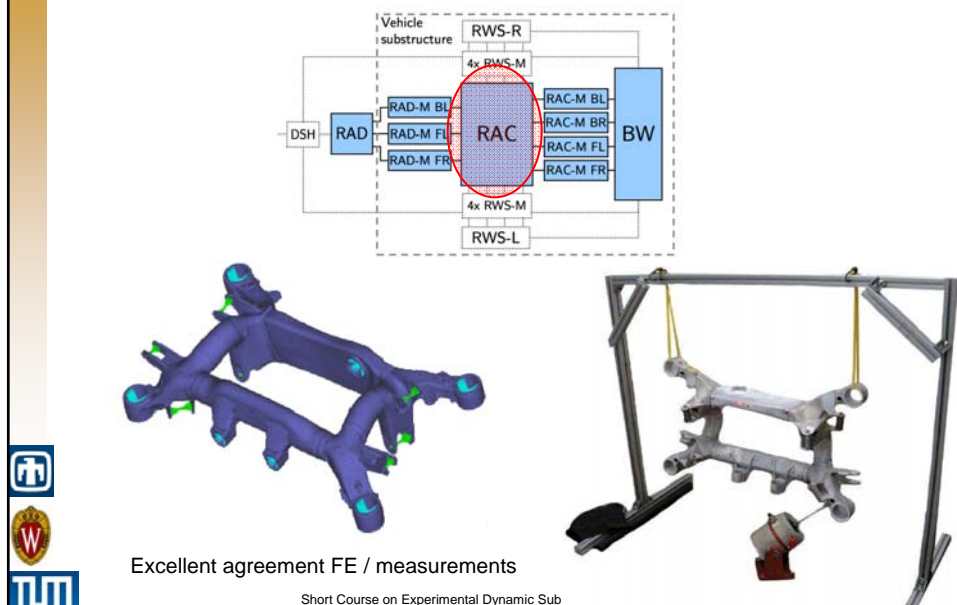
only FE model



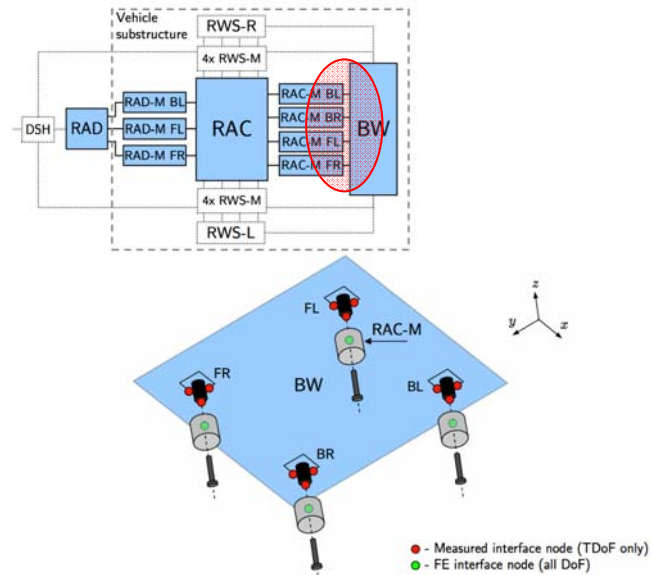
Example 1 – FBS on a full car



Example 1 – FBS on a full car



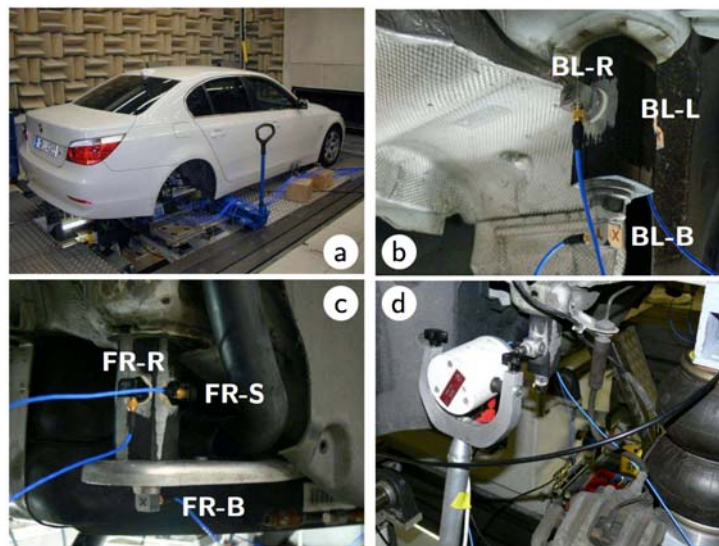
Example 1 – FBS on a full car



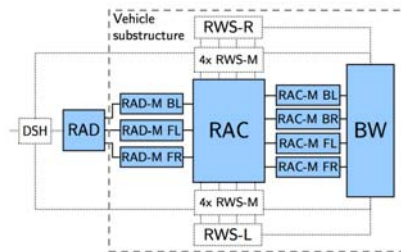
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Example 1 – FBS on a full car

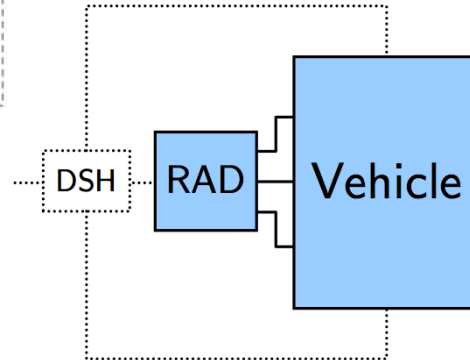
Body in white



Example 1 – FBS on a full car

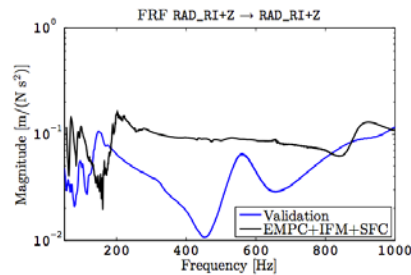


only 2 components RAD + rest

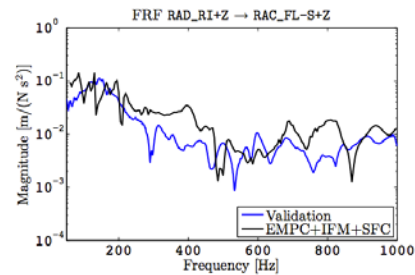


Example 1 – FBS on a full car

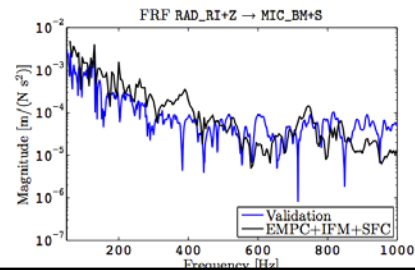
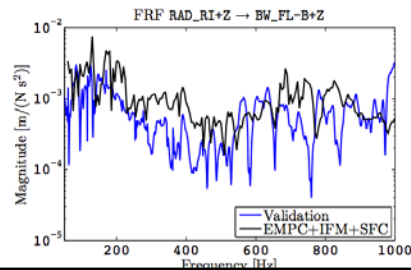
Validation results



(a)

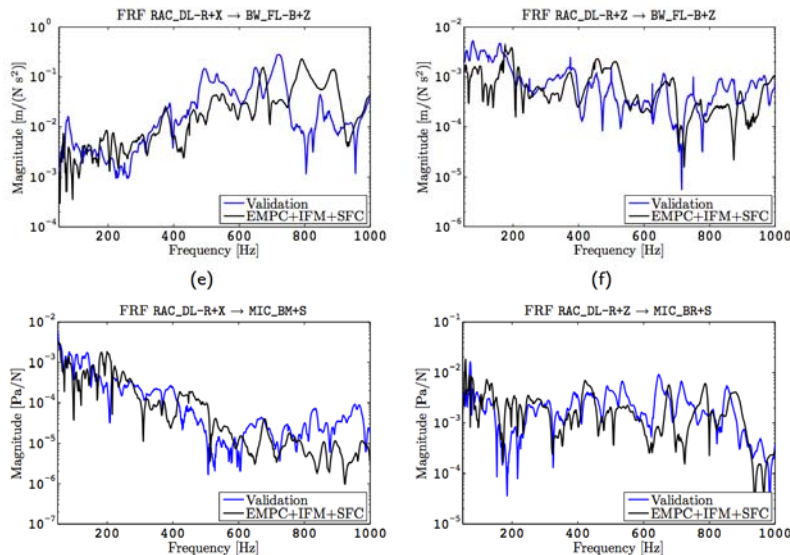


(b)



Example 1 – FBS on a full car

Validation results



Example 2 – FBS on steering gear assembly

This work is currently performed by Maarten vd Seijs

(D. de Klerk & D. Rixen supervisors)

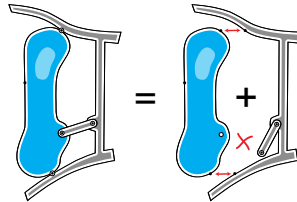
Extracts from

M. van der Seijs, D. de Klerk, D. Rixen, and S. Rahimi. Validation of current state frequency based substructuring technology for the characterisation of steering gear – vehicle interaction. In *IMAC-XXXI: International Modal Analysis Conference, Garden Grove, California USA*, Bethel, CT, February Feb. 11-14, 2013. Society for Experimental Mechanics.

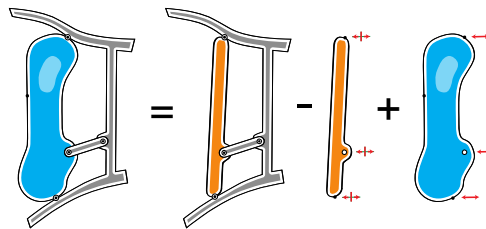
M. V. van der Seijs, D. D. van den Bosch, D. J. Rixen, and D. de Klerk. An improved methodology for the virtual point transformation of measured frequency response functions in dynamic substructuring. In M. Papadrakakis, V. Papadopoulos, and V. Plevris, editors, *COMPdyn 2013 4th ECCOMAS Thematic Conference on Computational Methods in Structural Dynamics and Earthquake Engineering*, Kos Island, 12-14 June 2013.

Example 2 – FBS on steering gear assembly

Aim: predict the vibration transfer between steering gear and steering wheel



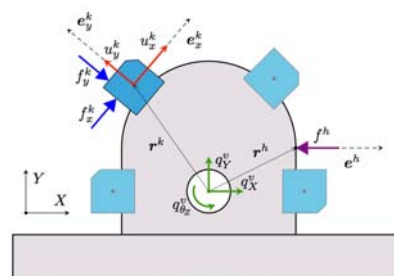
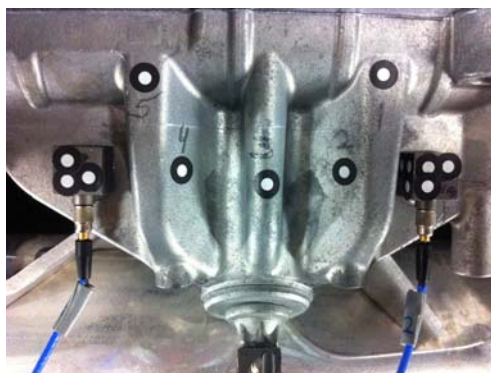
Use of a substitute during component measurement of to improve measurements (see MOD08)



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Example 2 – FBS on steering gear assembly



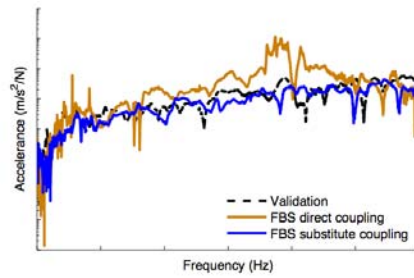
FRFs on connecting points measured with EMPC technique and positions of sensors measured by photogrammetry

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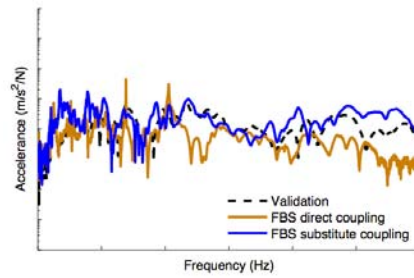
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Example 2 – FBS on steering gear assembly

Validation results



(a) Transfer between the bolted connections points.



(b) Transfer from the steering gear to the steering wheel.

